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Abstract

CONTRIBUTIONS TO THE STUDY OF THE TECHNOLOGY OF THE COMPOSITES Al-Al_2O_3 IN VIEW OF NUCLEAR APPLICATIONS

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The work described in this paper is part of a research on the technology of Al-Al_2O_3 composites sponsored by Euratom in connection with the Orgel project and carried out at the Istituto Sperimentale Metalli Leggeri (Laboratories of Novara, Italy).

In the first part of the work, commercial powders were used. These were produced up to mid-1962 by Alusuisse (the Swiss company which has the original SAP patents) and later on by Eckart Werke (Germany) with the following content of oxide:

SAP 960 with 4% Al_2O_3 ca.
SAP 930 with 7% Al_2O_3 ca.
SAP 895 with 10-11% Al_2O_3
SAP 865 with 13-14% Al_2O_3

The first improvement in the quality semi-finished product was obtained at the end of 1960 through a vacuum treatment of powders after cold compacting conducted at 600-625°C for about 20 hrs. (according to a patent filed in May 1961). The obtained material (named SAP-ISML) presents:

1) a quantity of the residual gas much lower than in previous products: less than 10 ppm;

2) a good thermal stability of the material at high temperature (up to 600°C) and, thus, a marked improvement in the welding possibilities.

These first improvements made it possible to effectively consider SAP as a material for nuclear applications (canning of fuel elements and tubing for the organic coolant).

The second improvement was obtained in the production of semi-finished products and has led to the manufacture of canning sheaths and tubing for the coolant which present the close tolerances required and on which are no longer observed - not even after thermal treatment at high temperature - such defects as blisters, microcracks etc., as were previously observed on commercial SAP.

This paper reports the main properties of the 4 qualities of SAP-ISML, at room temperature and at high temperature, creep behaviour and other technological and mechanical properties with the tolerances at present obtained on the production of canning material (straight and finned tubes) and of straight tubing for organic coolant.

Some scattering in the mechanical properties is mainly due to insufficient homogeneity of the starting powder (variations in the content of Al_2O_3 and presence of impurities) and to the irregularity of oxide distribution.

It was possible to choose SAP-ISML 7% Al_2O_3 as the best material for canning and SAP-ISML 10% Al_2O_3 for large diameter tubing (and also as a limit quality for the production of canning sheath).

The study was continued in order to improve:

1) a property, so far unchanged, namely the low ductility at high temperature under a limited strain, and

2) the fabrication of the finished products, such as finned tubes, etc.

In the second part of the paper we examine another line of improvement of the composites Al-Al_2O_3, viz. the study of new powders with a minimum of impurities and in which the dispersion of the oxide is as fine and homogeneous as possible.

When coarse, such impurities as iron and silicon make the material more brittle at high temperature and also lower the quality of the material from the points of view of corrosion resistance and neutron economy.

On the other hand, the obtention of a finer and more homogeneous dispersion of the oxide particles in the aluminium matrix should give at the same level of oxide a better group of properties of the finished products, more isotropy and less brittleness.

For these reasons a study was started in mid 1962 on the powder study that has led to a product called Atomal (according to a patent filed in April 1963).

This paper describes the fabrication procedures of Atomal and this material's main properties i.e.:

1) Oxide content: it may be chosen in the range 2-15% with scatter of ± 0.5% of the chosen value;

2) Impurities: iron and silicon are both below 0.01%. Other impurities are within the limits accepted for nuclear aluminium;

3) Homogeneity: the distribution homogeneity of oxide in Atomal powders was found superior to the normal commercial SAP powder;

4) Mechanical properties: at the same oxide level, an Atomal finished product has a better ductility and more isotropy than the conventional SAP products.